Torrential Potential of Desert Waters

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TORRENTIAL POTENTIAL OF DESERT WATERS

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On Monday evening, August 13, 1923, several localities in northern Utah were visited by the most devastating floods known in local history.

It will be recalled that Utah is traversed from north to south by a narrow, central highland that cuts the state into two areas of nearly equal size. The northern half of this highland constitutes the Wasatch Mountains, along the western base of which is situated the great Wasatch fault. The country immediately adjacent to the mountains to the westward is comparatively level, interrupted here and there, however, by island-like mountains that arise from the sediments of ancient Lake Bonneville. The western face of the Wasatch Mountains, which constitutes the dissected escarpment of the Wasatch fault, is relatively steep throughout its entire length of 150 miles. At many places it attains true Alpine ruggedness while at others it recedes to somewhat lower slopes.

The Wasatch Mountains give rise to a large number of canyon streams most of which flow directly to the westward and finally contribute their waters to Great Salt Lake. At points where the streams leave the steep grades of the canyons and enter upon the much lower grades of the adjacent area, alluvial fans, often of large dimensions, are constructed. The great size of many of these alluvial fans is made possible by being superimposed upon deltas previously deposited in similar positions by the waters of Lake Bonneville.

These alluvial fans were particularly attractive to the early settlers of the country, since in most cases they provided an easily accessible supply of irrigation water and an abundance of good

soil — both indispensible to agriculture in an arid region. The reclamation of Utah was, therefore, begun almost exclusively on these alluvial deposits close to the western face of the Wasatch Mountains. The towns were spread out over the distal slopes of the fans. Even today Utah's agricultural activity is largely centered around these areas, although of more recent years the great canal systems have reclaimed vast tracts of land not so easily accessible to the early settlers.

Streams arising in the Wasatch Mountains are all comparatively short and, therefore, contain but small quantities of water. The annual precipitation in northern Utah is less than twenty inches, part of which falls in the form of snow and is retained until spring when it runs off as swollen streams. During the greater part of the year the streams are normally small and quite inoffensive.

Laymen generally have paid but little attention to the fact that arid and semi-arid regions are often ones of intense stream activity. It is doubtful that even geologists and engineers have given this matter the attention it deserves. The building of railroads and other commercial enterprises, such as factories and power plants, immediately adjacent to apparently safe streams is by no means an unknown practice in many of our western states. The occasional flooding of a stream, with its attendant destruction, is often regarded as an unforseeable accident rather than as something to be expected. A certain western railroad was visited by destructive floods for nearly a dozen years before the engineers were seemingly convinced that it is unsafe to build a roadbed close to the edge of a stream in an arid region.

The principal cause of flooding in such places is, of course, the unequal time-distribution of precipitation. Long continuous rains are seldom known; on the other hand, sudden storms are the rule, especially during the summer season. The entire precipitation of a comparatively long period may be confined to a few minutes or a few hours, in which case the run-off is very rapid. The run-off is also unusually large in comparison with seepage and evaporation.

The rainstorm of August 13, 1923, was the most intense of local record. It gathered slowly during the afternoon without unusual manifestation of either lightning or wind; but just before 7

o'clock it broke with extreme suddenness and severeness at several places along the western face of the Wasatch Mountains. At Salt Lake City during five minutes of the storm .35 inches of rain fell, which at the end of half an hour reached 1.05 inches. The total precipitation of the storm for two hours was 1.23 inches. During the period of greatest downpour 0.1 of an inch of water fell in precisely one minute.

The storm was characteristically one of local occurrence. A few miles west of Salt Lake City the rainfall was comparatively light; this was also the case near the crest of the range. Considerable variation in intensity was also noted at near-by places along the western base of the mountains. The points of greatest rainfall were apparently centered in the canyons east of Farmington and Willard, the former 15 miles north of Salt Lake City, and the latter 50 miles north of the same place. Official records of precipitation at these localities are not available, although the rainfall was probably not greatly in excess of that at Salt Lake City.

The towns of Farmington and Willard are both situated immediately at the western base of the Wasatch Mountains. Willard is located near the apex of a typical alluvial fan; while Farmington lies slightly off on the southwest side of a less perfectly developed one. Farmington canyon is about ten miles long; Willard canyon is slightly less than half this length. The elevation of the head of each of the canyons is three to four thousand feet above that of the towns. Before the storm, Farmington canyon was accessible by a fairly good wagon-road, but Willard canyon was too steep for vehicular travel.

It appears that in the Farmington region the rainfall began somewhat earlier in the mountains than at the town, since less than fifteen minutes after the town experienced its first downpour the flood-waters from the canyon streams were upon it. At Willard the flooding was slightly more tardy.

The suddeness and intensity with which the torrential streams rushed through the canyons and burst out into the open is grimly told by the loss of life, both of campers along the stream channel and of people in their homes. Stories are current of great "walls" of water ten or more feet in height that descended upon the towns with almost lightning-like velocity. These reports, however, lack confirmation, as the people had been driven into their homes by

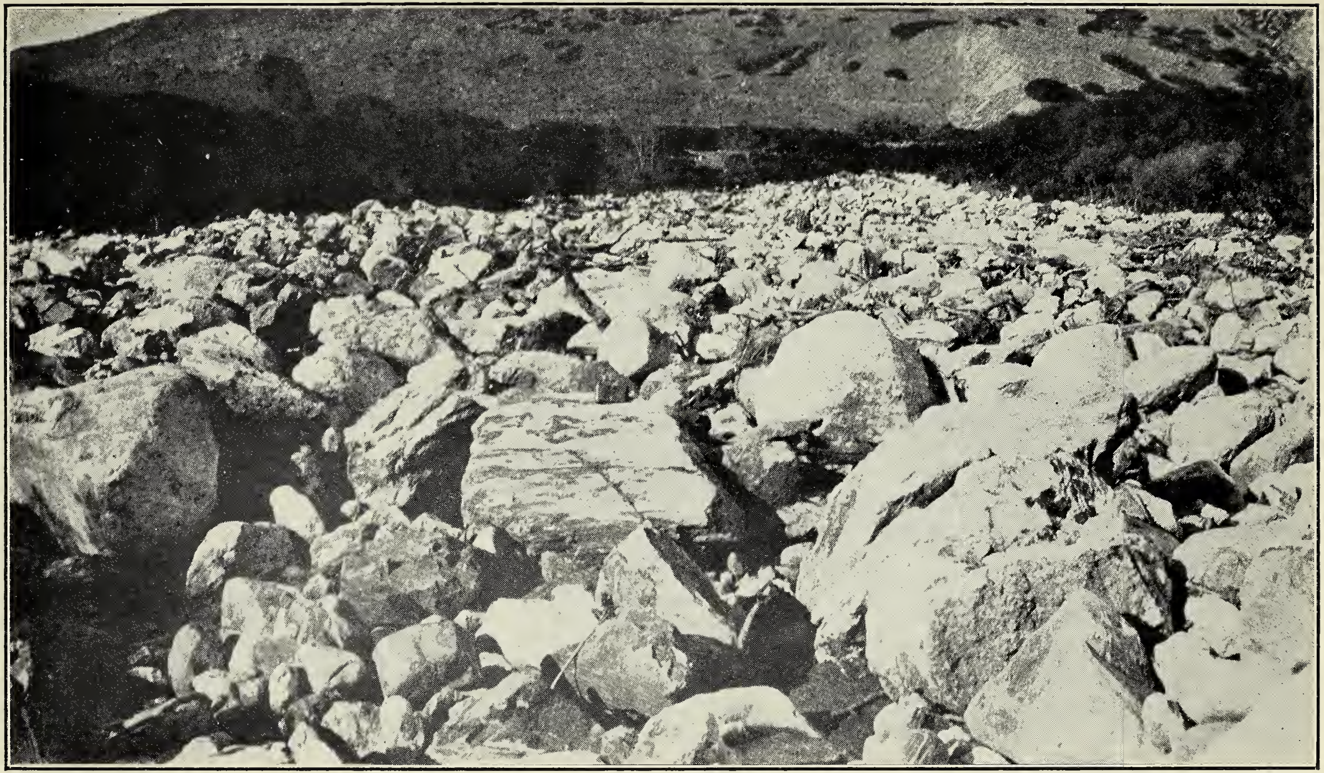
the intensity of the rainfall. Furthermore, the darkness of the evening made accurate observation largely impossible. The fact is that the flood was upon the people before they were really aware of its existence.

At Willard the flood sent two great streams of water, mud, and boulders almost directly through the center of the town; while at Farmington the devastation was limited to areas outside the main part of the village. Perhaps the outstanding feature of the flood at both of these places is the vast quantity of débris strewn along the lower stretches of its course. A total of more than five hundred acres was buried under rock waste. In Willard where the flood crossed the state highway the roadbed was covered for more than a city block by three to six feet of débris, mostly mud, gravel, and boulders. At several places near Farmington the highway was similarly affected. Nearly a score of residences were partly buried. In several cases the débris rushed into the open doors and covered the floors to a depth of one to four feet. Single boulders weighing as much as a thousand pounds have been removed from several of the buildings. The lighter out-buildings and hay-stacks were carried away completely.

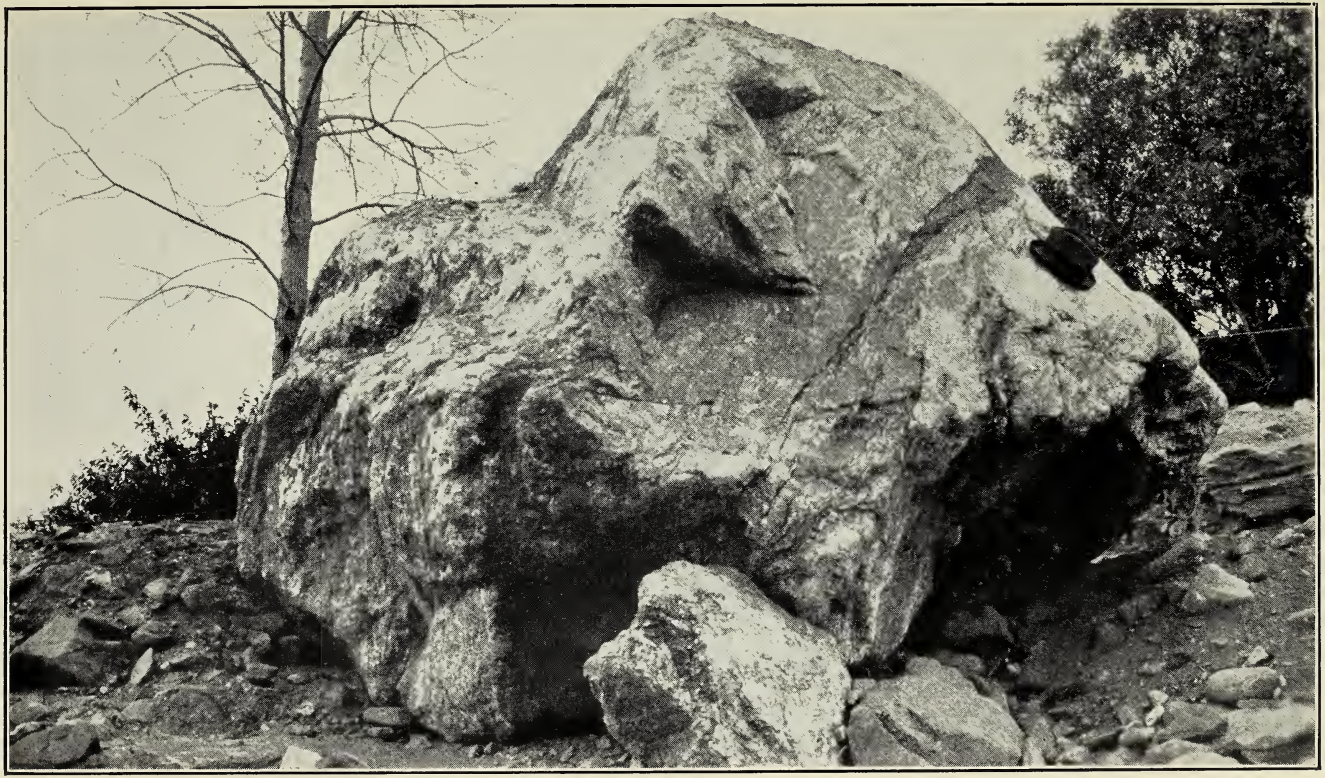
The extreme intensity of the flood was the result largely of certain local conditions within the canyons. The canyons themselves are narrow and sharply V-shaped. Before the flood the somewhat profuse vegetation grew immediately to the edge of the streams and often overhung them in such a manner as to fairly block the channels. The effect of this condition, coupled with that of the floating débris picked up by innumerable flooded tributaries, was to create a large number of temporary dams or obstructions along the course of the stream. One by one these empoundments were successively broken and their ever increasing contents were added to the one next lower down. By the time the mouth of the canyon was reached a gigantic volume overcame the last obstruction and burst out into the open with the violence of a collapsed reservoir.

Remnants of some of the dams still remain. The material consists largely of vegetable matter ranging from twigs up to trees one to two feet in diameter, all intimately gnarled, tangled, and heaped to heights as great as twenty feet. None of the dams, especially in the lower parts of the canyons, was able permanently

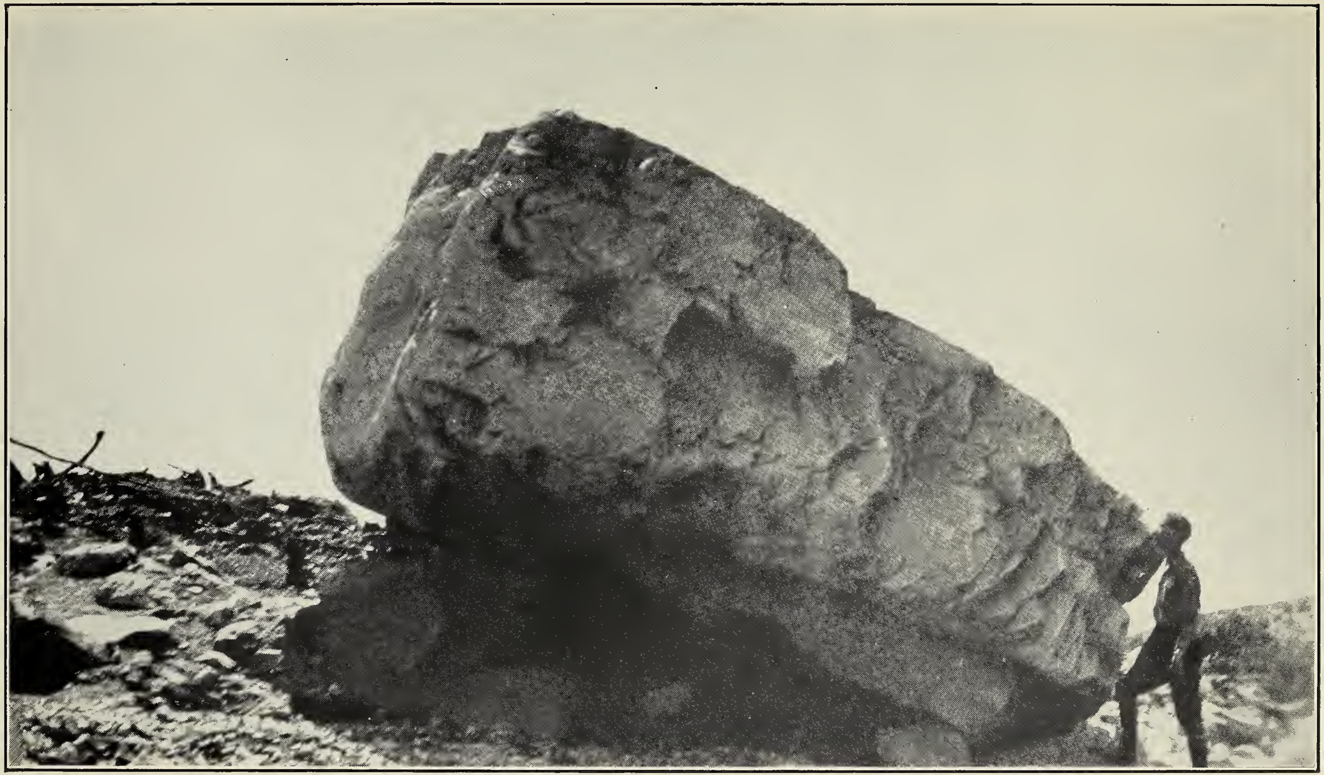
MOUTH OF WILLARD CANYON, WASATCH MOUNTAINS, UTAH



TRANSPORTATION OF BOULDERS BY FLOOD WATERS, FARMINGTON



FLOOD TRANSPORTED BOULDER WEIGHING FIFTY TONS



FLOOD TRANSPORTED BOULDER WEIGHING SEVENTY-FIVE TONS, AT WILLARD

to hold back the torrents. Not only the dams themselves were removed, but also all of the vegetation, large and small, along the courses of the former streams. The old stream-beds, in fact, were entirely destroyed and in their places channels were incised many times larger than their predecessors.

The period of flooding on the areas outside the canyons consisted essentially of three distinct phases; firstly, a short period of gradual increase of stream volume, secondly, a longer period of almost cataclysmic intensity and, thirdly, a still longer period of normal flooding, characterized at the beginning by highly swollen streams which gradually decreased to their ordinary size. These three phases were occasioned respectively by the water that preceded, accompanied, and followed the breaking of the temporary dams in the canyon streams.

The first phase of flooding was very short and probably caused but little damage. Seemingly, the water was confined to its channels and its work, therefore, consisted of transporting débris picked up along its course.

The second phase was the most destructive, also the most instructive. The first impulse of this phase carried with it vast quantities of woody material derived first from the collapse of the temporary dams along its channel. Slightly following this first impulse were tremendous quantities of rock-waste ranging in size from impalpable material to boulders of very large dimensions. These gigantic masses of heterogeneous material were shot from the narrow canyons into the open valleys with a suddenness that almost challenges belief.

The manner in which the rock débris was transported during this phase of the flood constitutes one of the most unusual aspects of the entire period of flooding. The fact is well known that streams usually transport rock-waste either by rolling, or in suspension, also minor quantities by shoving. In the case at hand much of the material, large and small, was transported in the manner named last. Evidences of shoving are shown (1) by the striations and flutings left in the soils and gravels along the margins of the stream, (2) by the heterogeneous manner in which the débris came to rest, and (3) by the abrupt margins of the deposits. When the temporary reservoirs broke the momentum of the water set in motion gigantic quantities of rock waste that rushed toward

the valley in a manner somewhat resembling that of great mud flows. Note should be made, however, that the inclination of the slope down which this material traveled varies between eight and four degrees. These flows seemed to have reached the valley somewhat behind the major part of the water that initiated their movements and in places almost entirely unaccompanied by it.

The striations and flutings of this sliding mass of rock-waste were impressed upon the clays and other compact soils along the margins of the flood streams, locally giving rise to rounded topography somewhat resembling that produced by glaciation. Then again, where this sliding mass crossed the highway the cement is scratched by a series of parallel marks made by the passing boulders. Similar striations are also present on several large iron pipes over which the flood passed. Trees and undergrowth were not pressed down as they would have been by rolling boulders but were cut off at the ground almost as if a great knife had passed through them.

The absence of water as in immediate transporting agent is also shown by the heterogeneous manners in which the timber, soil, gravel, and boulders of all sizes are heaped into masses not possessing the slightest approach toward sorting or stratification. Moreover, as the floods of mud and coarser débris passed by houses and other stationary objects the high marks were made by mud, not by water, showing the near-absence of the latter at the precise time of the greatest deposition of débris.

Of at least equal interest is the abrupt manner in which the margins of the flood deposits terminate. This condition is illustrated by a strawberry field which was covered by débris to a depth of 3 to 4 feet, while nearby the field was untouched. The soil immediately at the margin of the débris was not flooded with sufficient water to run down the shallow furrows separating the rows. Then again, within a rod of the back door of a residence the margin of the débris is fully two feet high and yet no water whatever reached the house.

The characteristic features of the second phase of flooding therefore consisted of two parts, firstly, an impulse of water carrying with it large quantities of timber and other floating débris that came largely from the breaking of the temporary dams, and, secondly, a great flow of mud consisting of fragments, large

and small, derived chiefly from the rock-waste that had accumulated along the upper stretches of the stream. The impulse of water seemingly followed somewhat closely along the old channel, but the mud flow could not conform to the minor irregularities of the stream bed and, therefore, at sharp turns it left the old channel and made for itself a new course, always quite straight, sometimes almost mathematically so. The channels made by the mud-flows were broadly U-shaped in cross-section.

The mud-flows were not equally developed in all of the localities where flooding occurred. They were particularly active at South Farmington and at Willard. Half a mile above the latter town the mud-flow left the water-channel and sent a gigantic tongue of débris almost directly through the center of the village. At South Farmington somewhat similar conditions resulted, although less intense.

The third phase of the flooding was not unusual, except probably in the matter of its violence. After the canyons had been largely cleared of obstructing materials, in the form of timber and undergrowth, the streams, then flowing more steadily, settled to the task of digging the old channels wider and deeper. Tremendous volumes of water rushed down the stream-channels carrying with them correspondingly heavy loads of rock débris. The stream-channels were intensely corraded, particularly in the canyons and on the upper stretches of the alluvial fans. In places the débris deposited by the preceding mud-flows was incised sufficiently to permit the water to flow through them in fairly well-defined channels. Well-washed and well-sorted boulders and gravels were strewn along the water channels (see plate xxxvi), forming a bold contrast with the heterogeneous masses deposited by the mud-flows. Adjacent to the mouths of the canyons the broad U-shaped channels, produced by the mud-flows, were replaced, sometimes in part and sometimes entirely, by steep-sided, flat-bottomed channels characteristic of water action.

By far the outstanding feature of the entire flood is the enormous size of the boulders carried by it. Literally thousands of boulders, weighing five to ten tons each, are strewn along its path. Toward the apices of the cones the boulders become larger. At Willard and elsewhere fully a score of boulders have been measured any one of which weigh 20 to 60 tons (plate xxxvii). The

largest boulder found is situated near the apex of the fan at Willard (plate xxxviii). It weighs very close to a hundred tons and was carried for half a mile down a slope of approximatly eight degrees inclination and then for nearly the same distance on a six-degree slope. It consists of quartzite and is roughly rectangular in form. Its dimensions, after due allowances were made for irregularities, were measured as follows: 14 feet from left to right, 7½ feet from bottom to top, 11 feet from front to back. Based on a specific gravity of 165 pounds per cubic foot, the mass weighs 190,575 pounds, or 95 tons.

The transportation of such enormous boulders was made possible by the singular manner in which they were carried. Field relations prove that all of the extremely large boulders came down with what we have chosen to call the mud-flows. Seemingly these mud-flows were initiated by the first great impulse of water occasioned by the breaking of the temporary dams in the canyon streams. It appears that this impulse of water slightly preceded the mud, which, of necessity, could not keep pace with the more limpid fluid that set it in motion. Furthermore, the impulse of water apparently followed the old stream channels, while the somewhat more slowly moving mud did not everywhere conform to them; in fact, in nearly all of the streams at some place or other the mud-flows "jumped the track" and went out on a tangent. This segregation of the materials makes it possible to determine the kind of medium in which almost any particular boulder was transported. In this connection it is interesting to note that very few of the boulders carried by the water alone weigh in excess of ten tons, while the largest ones transported in the mud-flows weigh nearly a hundred tons.

While the transportation of the large boulders may have been locally facilitated by the superior buoyancy of the mud, yet it should be remembered that the energy possessed by the mud was previously derived from the water. The mud-flow was not in any sense a slide occasioned by gravity; on the other hand, it was originally induced by the carrying power of water. The separation of the stream from its burden was due (1) to the superior velocity of the stream after leaving the mouth of the canyon, and (2) to the greater tendency of the mud-flow to depart from the irregularities of the stream channel.